Ground Water Investigation Program (GWIP - MBMG)
Overview of confined and unconfined aquifers

Presented to the Water Policy Interim Committee
July 13, 2012

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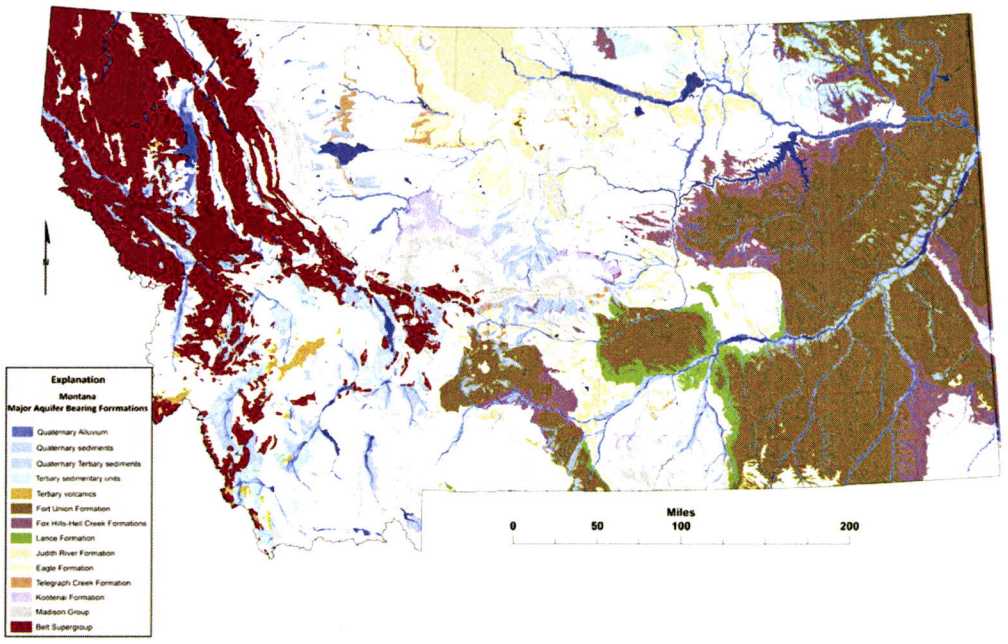
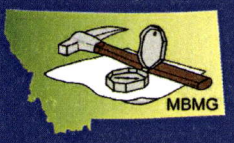




WPIC
July 13, 2012
Exhibit 1

Definitions and descriptions:

Unconfined: Aquifer open to atmosphere through pores in geologic material. These aquifer frequently have the best recharge and highest production.

Confined: Aquifer overlain by low permeability unit, such as a shale, that separates it from atmosphere. Slower response to recharge, better protection from contamination.

Pressure:

Atmospheric pressure at the water table in unconfined aquifer.
Greater than atmospheric at top of saturated zone in confined aquifer.
Pressure is measured by how high water raises in a well with an effective annular seal.

How aquifer is recharged:

Confined - local precipitation, loss from rivers, irrigation seepage.
Unconfined - regional precipitation. In unconfined areas, plus minor vertical leakage.

Where does water discharge:

Site specific, unconfined may discharge to river or deeper aquifer.
Confined may flow out of state, may form springs at outcrop, may flow to another aquifer.

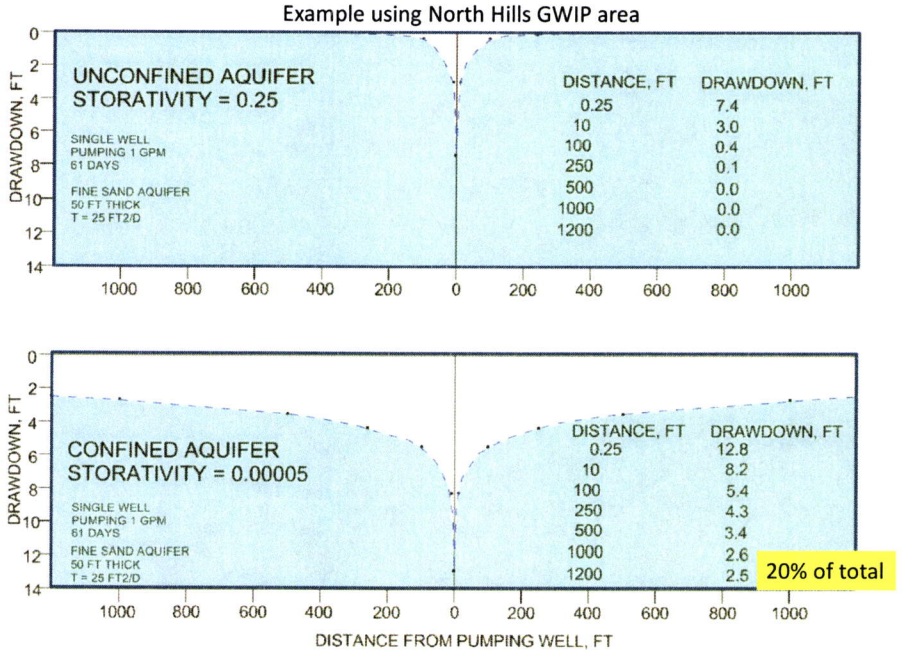
How water is produced:

Unconfined – drainage of pore space between geologic material. The volume of water produced may be in the range of 10 to 25% of volume of drained aquifer.
Confined - pressure reduction, can be 1,000 times less per foot change in head than unconfined.
Septic return may reach unconfined aquifer but not a confined aquifer.

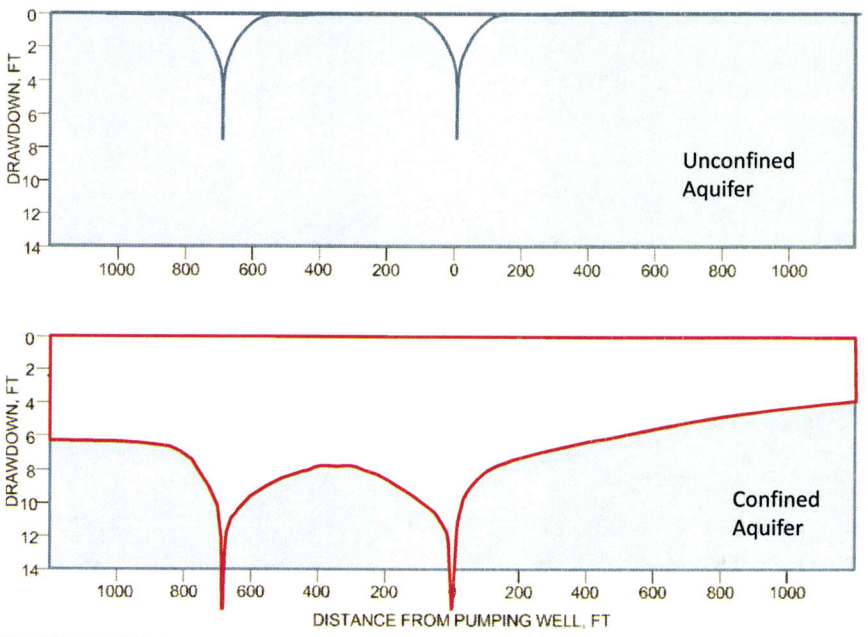
Applied concepts:

Immediate and direct connection to surface water – unconfined aquifer near stream
Delayed and direct – unconfined aquifer distant from stream
Delayed and indirect – confined aquifer

Continuing the discussion of confined and unconfined aquifers
Example using North Hills GWIP area



Continuing the discussion of confined and unconfined aquifers



Unconsolidated aquifers

Unconsolidated

Fort Union Fm

Fox Hills/Hell CK Fm

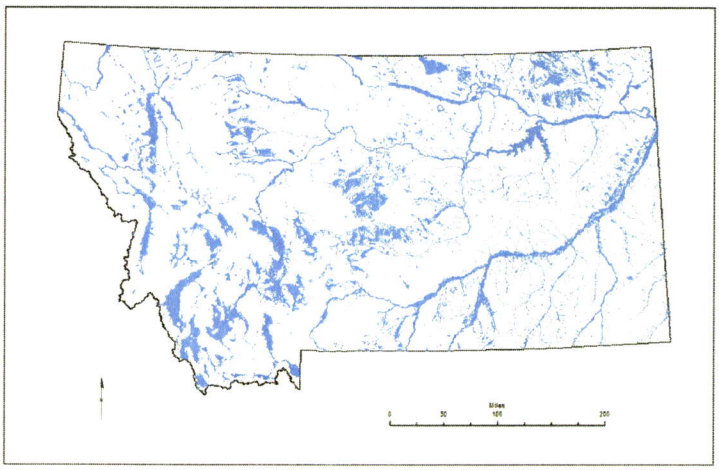
Judith River Fm

Eagle Fm

Kootenai Fm

Madison Gp

Belt Gp



Wells completed in unconfined aquifers
37,040 wells

Unconsolidated

Fort Union Fm

Fox Hills/Hell CK Fm

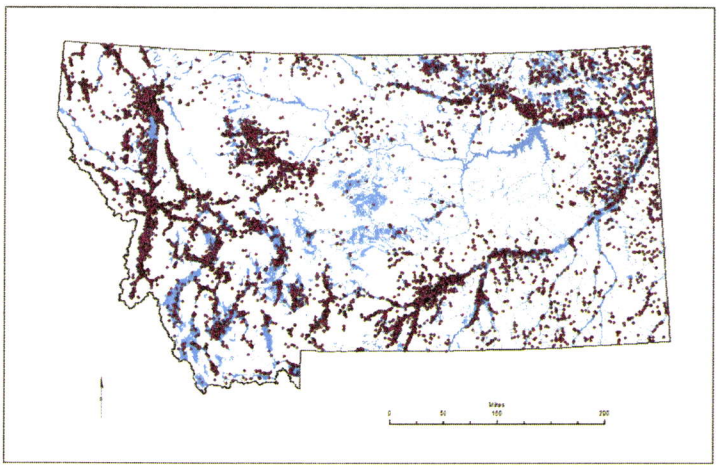
Judith River Fm

Eagle Fm

Kootenai Fm

Madison Gp

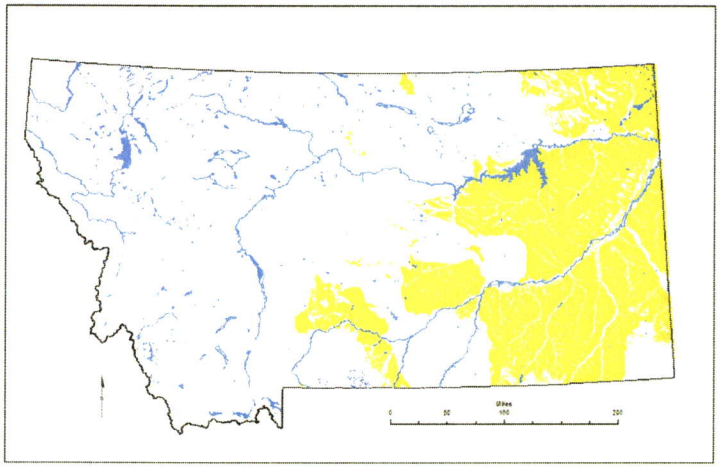
Belt Gp



Based on the Montana State geologic map and drillers logs in the Montana Ground Water Information Center (http://mbmggwic.mtech.edu/). For this analysis those wells completed in unconsolidated geology at shallow depths showing water-table static water depths were classed by a hydrogeologist as completed in unconfined aquifers. Includes wells with unconfined aquifer characteristics, showing water-table water levels and completed in major aquifer bearing formations.

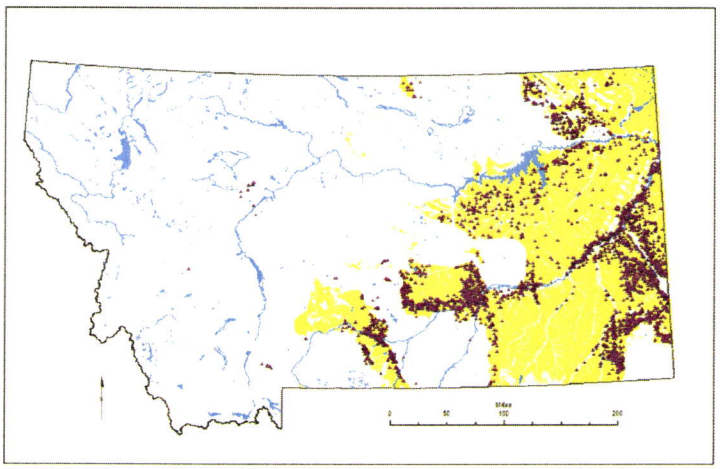
Fox Hills/Hell Creek/Lance Formations

Unconsolidated
Fort Union Fm
Fox Hills/Hell CK Fm
Judith River Fm
Eagle Fm
Kootenai Fm
Madison Gp
Belt Gp



Wells completed in confined aquifers in Fox Hills/Hell Creek/Lance Formations
5,585 wells

Unconsolidated
Fort Union Fm
Fox Hills/Hell CK Fm
Judith River Fm
Eagle Fm
Kootenai Fm
Madison Gp
Belt Gp



Based on the Montana State geologic map and drillers logs in the Montana Ground Water Information Center (http://mbmggwic.mtech.edu/). For this analysis those wells with water levels rising in well casing above confining layers and determined by a hydrogeologist to be completed in the Fox Hills, Hell Creek, or Lance Formations.

Wells completed in confined aquifers in unconsolidated formations
18,890 wells

Unconsolidated

Fort Union Fm

Fox Hills/Hell CK Fm

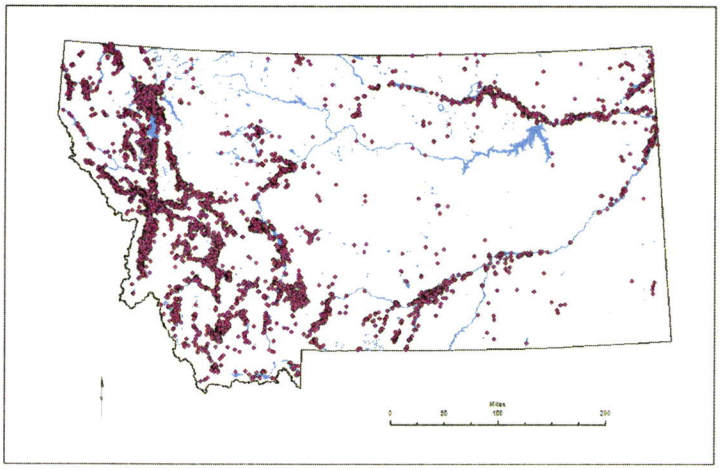
Judith River Fm

Eagle Fm

Kootenai Fm

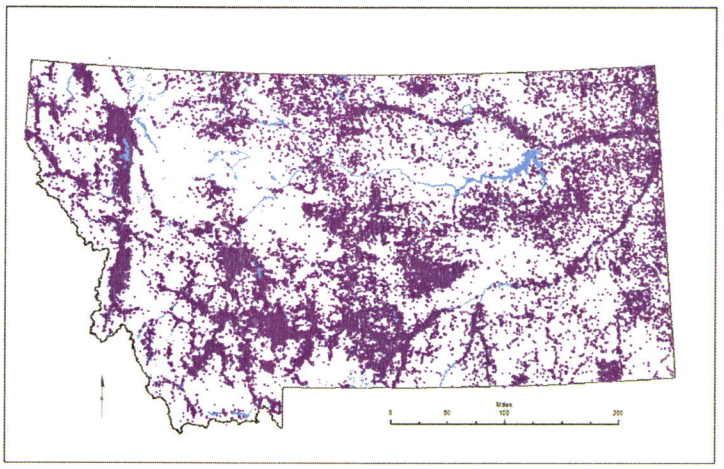
Madison Gp

Belt Gp

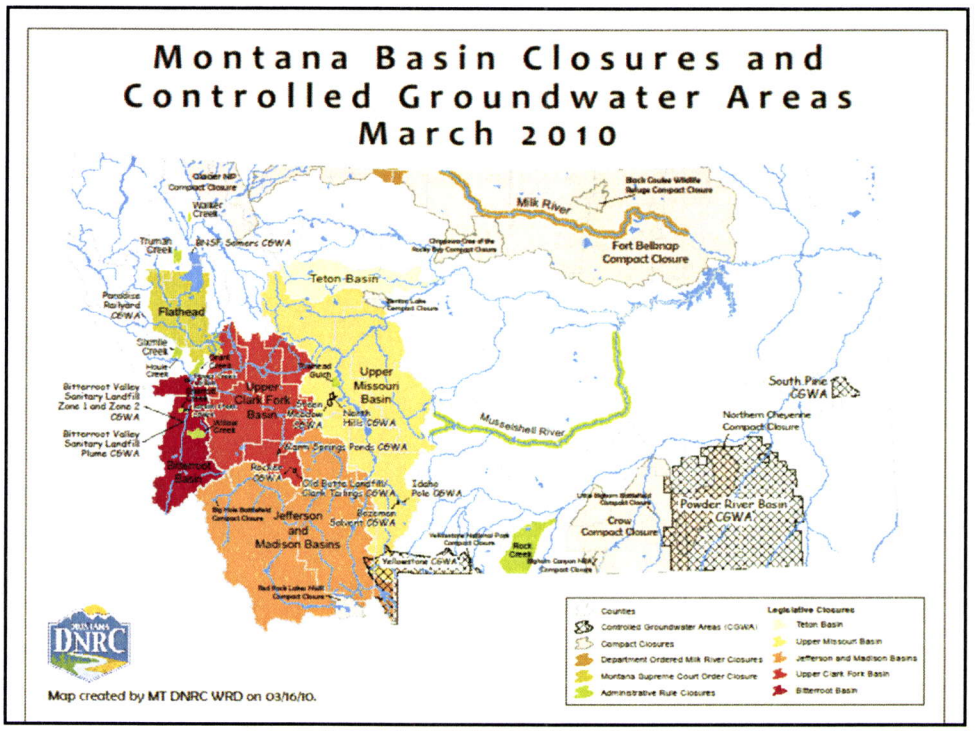


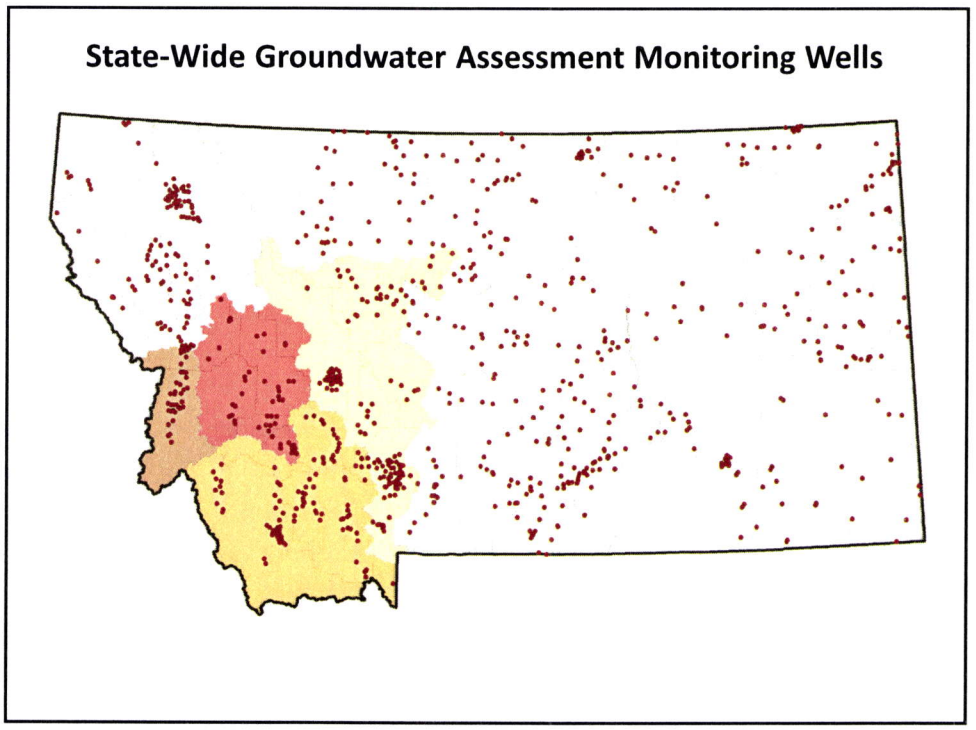
Based on the Montana State geologic map and drillers logs in the Montana Ground Water Information Center (http://mbmggwic.mtech.edu/). For this analysis those wells completed in unconsolidated geology with water levels rising above a confining layer were classed by a hydrogeologist as completed in confined aquifers.

Wells in GWIC not coded to an aquifer
117,400 wells



Based on the Montana State geologic map and drillers logs in the Montana Ground Water Information Center (http://mbmggwic.mtech.edu/). For this analysis those wells on file in the GWIC database that have not been assigned to an aquifer.


Montana Basin Closures and Controlled Groundwater Areas March 2010
Milk River
Fort Belknap Compact Closure
Teton Basin
Flathead
Upper Clark Fork Basin
Upper Missouri Basin
Musselshell River
South Pine CGWA
Northern Cheyenne Compact Closure
Powder River Basin CGWA
Crow Compact Closure
Jefferson and Madison Basins
Idaho Pole CGWA
Rocker CGWA
Warm Springs Ponds CGWA
Old Butte Landfill/ Clark Tailings CGWA
Bozeman Solvents CGWA
Yellowstone CGWA
Bitterroot Valley Sanitary Landfill Zone 1 and Zone 2 CGWA
Bitterroot Valley Sanitary Landfill Plume CGWA
Counties
Controlled Groundwater Areas (CGWA)
Compact Closures
Department Ordered Milk River Closures
Montana Supreme Court Order Closure
Administrative Rule Closures
Legislative Closures
Teton Basin
Upper Missouri Basin
Jefferson and Madison Basins
Upper Clark Fork Basin
Bitterroot Basin
Map created by MT DNRC WRD on 03/16/10.


State-Wide Groundwater Assessment Monitoring Wells